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Patentanmeldung Nr. Patent application No. Demande de brevet n°

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If no title is shown please refer to the description.
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Switchable colour filter based on electro-wetting

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Switchable colour filter based on electro-wetting

Technical field

In many electronic consumer devices colour filters are used. For instance, in (digital) photo and (security) cameras, a cyan colour filter is used to switch between day and night sensitivity. Another field where (switchable) colour filters are used is the one of projection systems, where the different colour images are overlaid by time sequential projection.

Technical problem.

Currently, mechanical options are used in most cases. Drawbacks of such options are that these systems are generally bulky and have a limited lifetime.

Technical measure and effect.

We propose to use electro-wetting as a method to realise a non-mechanical tuneable colour filter. The basic system and principle are illustrated in fig. 1.

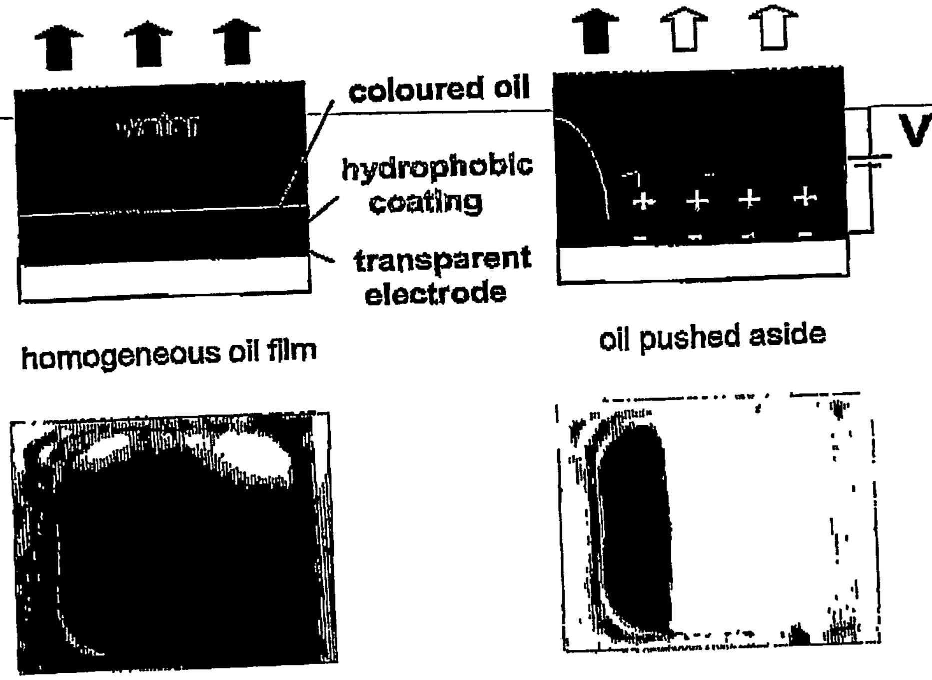

Figure 1 – Principle of switchable colour filter based on electro-wetting (top panels). Demonstration of feasibility (lower panels). The size of the device is 5x5 mm^2.

On the left hand side of the Figure no voltage is applied to the electrodes. In this case the oil film has a substantially uniform thickness over the cross-section of the radiation beam, indicated by the arrows. The oil film has a homogeneous transmission and is therefore active as a colour filter. On the right hand side, the oil is moved to the side by the application of a voltage to the electrodes. The filter becomes transparent in most of the active area. In this particular case, a white scattering substrate is placed behind the device, rendering the white colour where the oil has been removed.

An advantage of the filter is its relatively small height and the uniformity of the transmission of the filter over the cross-section of the radiation beam.

The practical demonstration in this case was achieved by using line electrodes, but other configurations are possible as well. A circularly symmetric electrode will push the oil to the side resulting in a circular transparent opening. If intermediate states, in which the

size of the transparent hole is varied, are desired, several concentric ring electrodes can be used. The oil can also be collected in a corner, by having a homogeneous electrode with a small square cut in one of the corners.

A circular motion can also be achieved by initiating the motion from the centre of the device. A possibility is a small reduction of the height of the oil layer in the centre of the device, for instance by a small increase in the height of the bottom of the device. Another possibility is a small modification of the surface at the centre by making it locally more hydrophilic. This may be achieved by a thin protrusion from the bottom, possibly extending through the oil layer, the protrusion having a hydrophilic surface. There are several other options to steer the oil into the desired direction. One can use an insulator layer or contact layer with a varying thickness. For example, if a radially varying insulator thickness is used with the smallest thickness in the centre, the oil motion will be initiated in the centre, i.e. at the highest field, and move outward. Other thickness variations are also possible. One can also vary the interfacial tension along the walls of the filter, and thereby create a preference for the oil motion.

Using different dyes or pigments in the oil can alter the colour of the filter. The colour is not limited to the visible wavelength spectrum, but could also be active in, for instance, the UV. If the oil is substantially opaque, for instance by the addition of a black dye or pigment, the filter operates as a diaphragm. It is possible to add light-scattering particles to the oil, making the filter diffusely reflecting.

In small systems (< 5mm diameter) the surface tension is sufficiently strong to ensure stability of the device upon rotation. Larger systems can be obtained by carefully matching the density of the oil and the water.

Switchable diaphragm based on electrowetting

Technical field

In many electronic consumer devices, diaphragms are used. An example of such an application area is the use of a switchable diaphragm in optical recording. Here, a diaphragm can be used to alter the size of the incident beam and thus the numerical aperture of the beam. This modulation of the entrance pupil diameter can be employed in CD/DVD or (CD/)DVD/BD compatible light paths in which the switching of the diaphragm is used to alter the numerical aperture of the beam for the corresponding disc type (CD, DVD, BD).

The modulation of the entrance pupil diameter can be employed as well during switching between the reading and the writing mode in optical recording. The writing of the marks on a phase change disc depends on the temperature profile of the spot on the disc; hence the central peak of the spot determines the resolution. In the writing mode, the side lobes of the spot have almost no effect. As a result, the writing process is less sensitive to disc tilt. On the other hand, the central peak and the side lobes of the spot are of importance for the process of reading. The side lobes can give rise to cross-talk due to the neighboring tracks. Hence the reading mode is more sensitive to disc tilt than the writing mode. With a switchable diaphragm it is possible to use a larger beam (higher NA) in the writing mode, resulting in a smaller central peak of the spot and in more power on the disc. This improves the write properties while still being tolerant for disc tilt. In the reading mode a smaller beam (low NA) can be used resulting in a beam having a higher rim intensity without being too sensitive for disc tilt. In this way, the switching of the diaphragm can improve both the read and the write properties in optical recording.

Another field of application is that of (digital) photo and (security) cameras. Here, the diaphragm regulates the light intensity on the film or CMOS/CCD sensor, which allows for a larger range in lighting conditions. Furthermore, the diaphragm can be used to change the depth of field.

Technical problem.

Currently, mechanical options are used in most cases. Drawbacks of such options are that these systems are generally bulky and have a limited lifetime. Furthermore, these options often only have a limited number of well-defined states.

Technical measure and effect

We propose to use an electro-wetting filter as a diaphragm to realize a non-mechanical continuously tunable diaphragm.

Embodiments

In the first embodiment we use the switchable diaphragm to vary the numerical aperture of the beam from NA=0.45 in the CD case to NA=0.65 in the DVD case. In figure 2 a light path is shown where the switching diaphragm is positioned in front of the objective lens OL. Preferably the device is integrated directly on top of the objective lens.

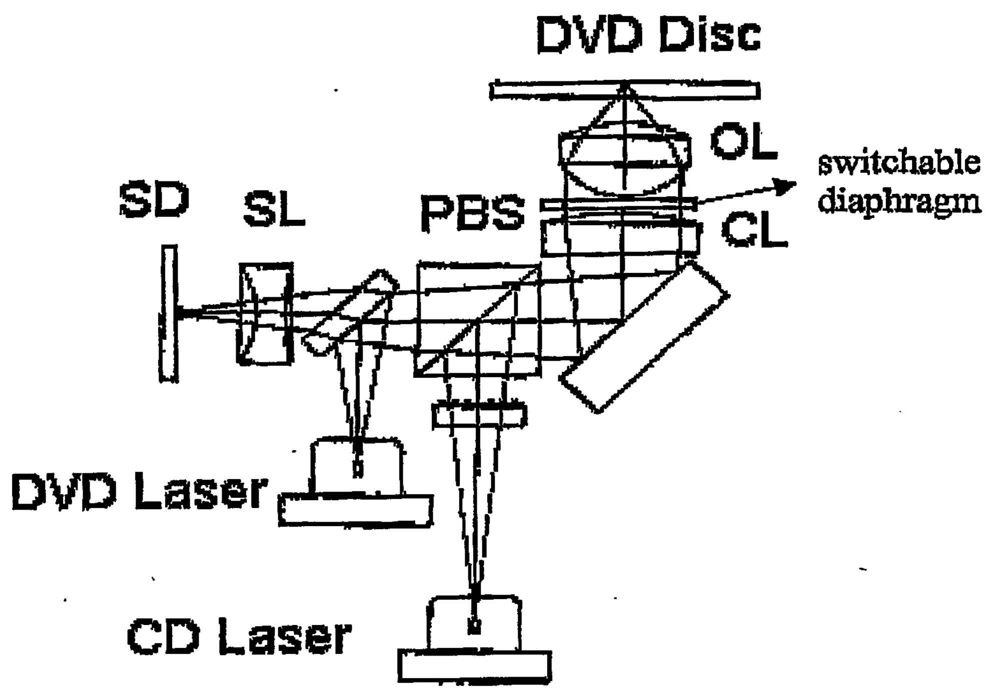

Figure 2 –The CD/DVD light path containing a polarising beamsplitter (PBS), a collimator lens (CL) an objective lens (OL), a servo lens (SL) and a switchable diaphragm according to the invention.

In an even more preferred embodiment the switchable diaphragm can also be used to switch the numerical aperture of the DVD beam from NA=0.65 for the writing mode to NA=0.6 for the reading mode. The corresponding improvement of the system is outlined in the "technical field" section given above.

Note that it is also possible to switch the entrance pupil from a circular entrance shape to an elliptical entrance shape. As a result the spot on the disc becomes elliptical as well (the orientation of the long axis of the spot and that of the entrance pupil are

orthogonal). With proper orientation of this elliptical spot on the information layer the read/write properties can be further improved (ROS/TOS/DOS spot orientation).

Double non-mechanical colour filter based on electro-wetting

Technical field.

In many electronic consumer devices colour filters are used. For instance, in (digital) photo and (security) cameras, a cyan colour filter is used to switch between day and night sensitivity. Another field where (switchable) colour filters are used is the one of projection systems, where the different colour images are overlaid by time sequential projection.

Technical problem

When multiple colour filters are needed, the known, mostly mechanical, colour filters are simply stacked. As a result, the filter stack takes up a significant amount of space.

Technical measure and effect

We propose to create a single cell colour filter that is able to switch two colours, by using a so-called bi-layer electro-wetting cell. The basic principle of such a cell is illustrated in fig. 3

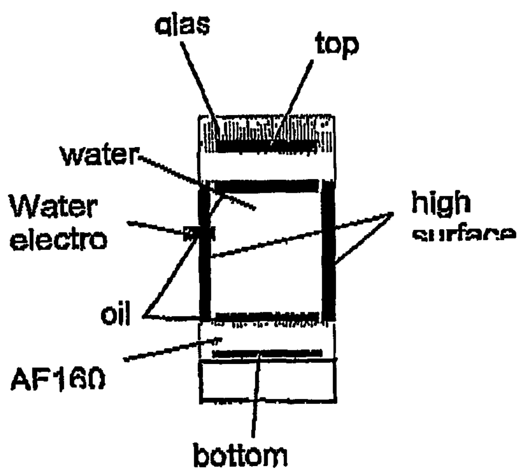

Figure 3 – Principle of bi-layer electro-wetting colour filter. The top and bottom oil layer can be switched independently.

In a bi-layer cell, the oil layer on top and the oil layer at the bottom are separated physically by using walls that are hydrophilic. In such a configuration, the oil layers can be switched independently by applying a voltage to the top and/or bottom

electrode, without risk that they will mix. The oil is separated from the top and bottom electrode by a hydrophobic layer of for example AF1600.

When no voltage is applied the oil film is homogeneous and therefore active as a colour filter. When a voltage is applied, the oil is moved to the side and the filter becomes transparent in most of the active area.

An advantage of the filter is its relatively small height and the uniformity of the transmission of the filter over the cross-section of the radiation beam.

A practical demonstration can be seen in fig. 3 where a top view photograph of a bi-layer cell is shown. This system has an inner diameter of 5 mm and we use a cyan top layer and a magenta bottom layer. Furthermore, we used an electrode structure with 3 lines on both the top and bottom plate and the lines are perpendicularly oriented with respect to each other. In the photograph of Figure 4, we applied a voltage to the middle electrode, resulting in different colours at different places in the device.

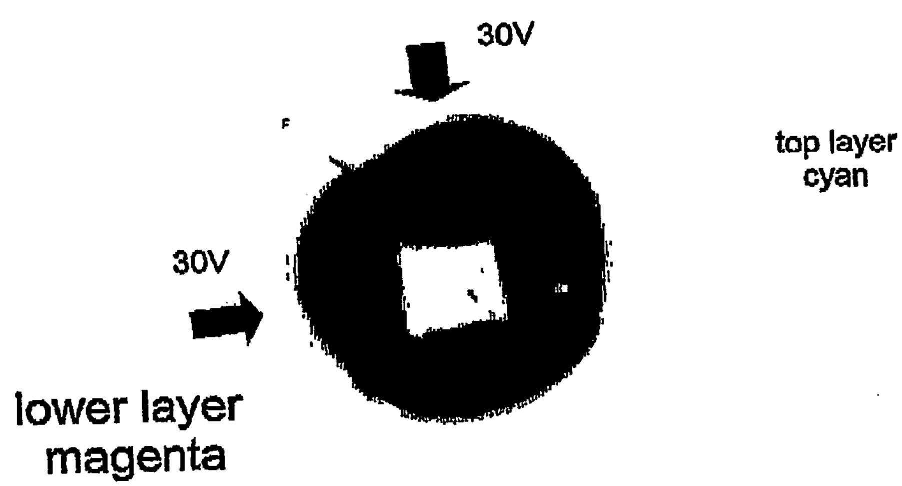

Figure 4 – Practical demonstration of the feasibility of a bi-layer electro-wetting cell.

Other configurations than the line electrodes are possible as well. A circularly symmetric electrode will push the oil to the side resulting in a circular transparent opening. If intermediate states, in which the size of the transparent hole is varied, are needed, several ring electrodes can be used.

The oil can also be collected in a corner of a square device, by having a homogeneous electrode with a small square cut in one of the corners.

A circular motion can also be achieved by initiating the motion from the centre of the device, for instance by slightly modifying the surface at the centre (making it locally more hydrophilic). There are several other options to steer the oil into the desired direction. One can use an insulator layer with a varying thickness. For example, if a radially varying insulator thickness is used with the smallest thickness in the centre, the oil motion will be initiated in the centre (at the highest field) and move outward. Other thickness variations are also possible. One can also vary the interfacial tension along the walls of the filter, and thereby create a preference for the oil motion.

Using different additives such as dyes or pigments in the oil one can alter the transmittance of the filter. When the transmittance has a non-uniform spectral distribution, the filter may be used as a colour filter. The transmittance change is not limited to the visible wavelength spectrum, but could also be active in, for instance, the UV.

In small systems (< 5mm) the surface tension is sufficiently strong to ensure stability of the device upon rotation. Larger systems can be made stable by matching the density of the oil and the water.

CLAIMS:

1. A switchable optical filter comprising a fluid chamber having an optical axis and including a first fluid and an axially displaced second fluid, the fluids being non-miscible, in contact along a first meniscus and having different transmissivities, the fluid chamber also including a first electrode in contact with the first fluid and a second electrode separated from the second fluid by a first contact layer, wherein the position of the second fluid is movable in a direction away from the optical axis by application of a voltage over the first and second electrodes, thereby changing the transmissivity of the fluid chamber in a direction along the optical axis.

2. The optical filter according to Claim 1, wherein the first contact layer is hydrophobic.

3. The optical filter according to Claim 1, wherein the second electrode is transparent and arranged in a plane perpendicular to the optical axis.

4. The optical filter according to Claim 1, wherein the first fluid is water and the second fluid is an oil.

5. The optical filter according to Claim 1, wherein the second fluid comprises an additive changing the transmissivity of the second fluid.

6. The optical filter according to Claim 1, wherein the specific mass of the first and second fluid are substantially equal.

7. The optical filter according to Claim 1, wherein the second electrode generates a increased field in the centre of the chamber.

8. The optical filter according to Claim 1, wherein the thickness of the first contact layer is non-uniform.

9. The optical filter according to Claim 1, wherein the thickness of the second fluid on the optical axis at zero applied voltage is smaller than the thickness around the optical axis.

10. The optical filter according to Claim 1, wherein the fluid chamber includes a third fluid axially displaced with respect to the first and second fluid, the first and third fluid being non-miscible, in contact along a second meniscus and having different transmissivities, the fluid chamber also including a third electrode separated from the third fluid by a second contact layer, wherein the position of the third fluid is movable in a direction perpendicular to the optical axis by application of a voltage over the first and third electrodes, thereby changing the transmissivity of the fluid chamber in a direction along the optical axis.

11. The optical filter according to Claim 10, wherein the second contact layer is hydrophobic.

12. The optical filter according to Claim 10, wherein the third electrode is transparent and arranged in a plane perpendicular to the optical axis.

13. The optical filter according to Claim 10, wherein the third fluid is an oil.

14. The optical filter according to Claim 13, wherein the second and third fluid have different spectral distributions of the transmissivity.

15. The optical filter according to Claim 10, wherein the specific mass of the first and third fluid are substantially equal.

16. An optical scanning device for scanning an optical record carrier, the device comprising a radiation source for generating a radiation beam, an objective system for transforming the radiation beam to a converging radiation beam focussed on the optical record carrier, and an adjustable diaphragm for controlling the numerical aperture of the converging radiation beam, characterised in that the diaphragm comprises an electrically controllable electro-wetting cell.

17. The optical scanning device according to Claim 16, in which the electro-wetting cell comprises the features of Claim 1.